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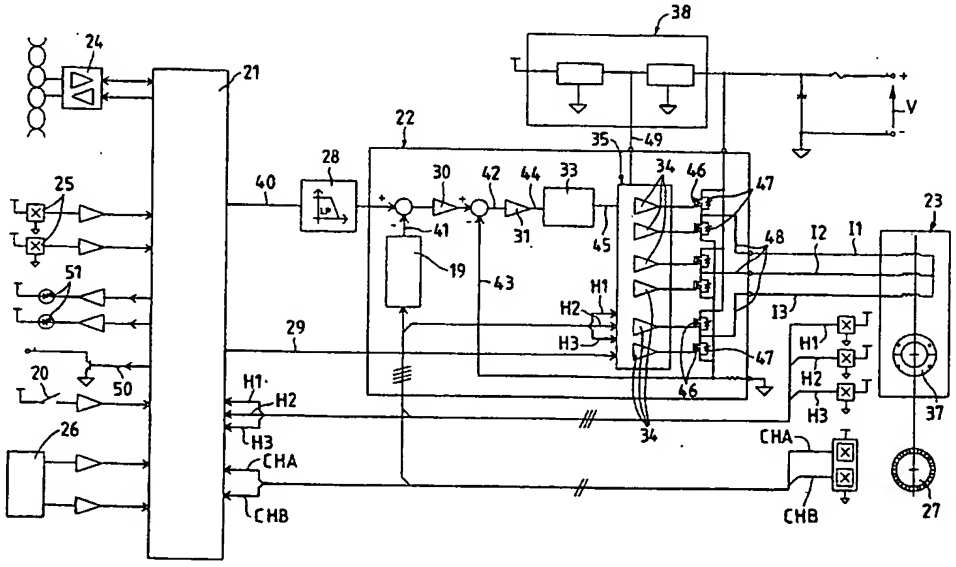
(54) **Title:** AN ELECTRONIC DEVICE FOR REGULATING AND CONTROLLING THE DELIVERY OF YARN COMING FROM FEED UNITS OF TEXTILE MACHINES



(57) **Abstract:** An electronic device for regulating and controlling the delivery of yarn (18) coming from feed units of textile machines, which is designed to vary the r.p.m. of a d.c. brushless motor (23) so as to keep it as synchronized as possible, according to an adjustable scale factor, with the speed of the textile machine served; the device comprises the d.c. brushless motor (23) and an electronic circuit based upon operation of a microcontroller (21) that is able to control the r.p.m. of the motor (23) and the currents (I1, I2, I3) in the phases of the aforesaid motor (23).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AN ELECTRONIC DEVICE FOR REGULATING AND CONTROLLING THE DELIVERY OF YARN COMING FROM FEED UNITS OF TEXTILE MACHINES

The present invention relates to an electronic device for regulating and controlling the delivery of yarn coming from feed units of textile machines.

Yarn-feed reels of a textile machine are usually set on the top frame of the machine or on a side reel-frame. In this connection, the side reel-frame occupies more space but enables an increase in the number of yarn feeds, the possibility of resorting to double feed at each drop, and the possibility of changing the empty reels more easily and rapidly.

On textile machines with rotating skirts, the reel-frame is fixed to, and set in continuous rotation with, the skirts themselves.

In any case, prior to arriving at the needles, the yarn follows a rather long path to give the machine time to stop before a possible broken end gets caught up.

Figure 1 shows a typical example of path of the yarn, designated by 18, which reels off the bobbin or reel 10, passes within a first thread-tightener 11 and in an arrest device 12, which operates both in the case of breaking of the thread and in the case of excess

tension. The thread-tightener 11 must be located as far as possible from the needles of the textile machine for the reasons mentioned above.

There follows a second thread-tightener 13 used for adjusting the tension to pre-set values, as well as a possible system 14 for controlling feed of the yarn.

Finally, there is envisaged the installation of a machine arrest 15, which acts in the event of breaking of the yarn 18.

In particular, on the most recent circular knitting machines, control of the feed is extremely important. For this reason, positive feeders can be used, which release to the needles a length of yarn that is as constant as possible in time, or accumulation feeders are provided, which maintain the tension of the yarn as constant as possible.

The positive feeder most widely used at the moment is the ribbon feeder (see Figure 2 attached), whereby a ribbon 16 runs all around the circumference 17, at each drop. The yarn 18 passes between the ribbon 16 and the wheel 19 and acquires the speed of the former so as to obtain a more uniform fabric, regulating the absorption on all the drops with just one operation in so far as, necessarily, all the threads of yarn 18 are fed the individual drops at the same speed.

Alternatively, control of the positive feeders of

the yarn can be obtained by means of interchangeable gears located in a special gear-case and by expandable pulleys with manual adjustment.

Adjustment of the expandable pulleys is carried out by slackening a belt, using a belt-tensioner, and then by releasing a ring nut using a pin provided so as to gain access to the plate of the pulley. It is thus possible to adjust the diameter by rotating the aforesaid plate of the pulley, which is provided with reference marks and, finally, to re-tighten the ring nut.

Upon request, further gears are available for different feeds of the yarn and arrangements of the textile machines to accept one-way or multiple-way positive heads, as well as different sizes of the belts.

A purpose of the present invention is therefore to overcome the drawbacks mentioned above and, in particular, to provide an electronic device for regulating and controlling delivery of yarn coming from feed units of textile machines which will enable adjustment of the delivery of yarn by varying the speed of a d.c. motor so as to keep it as synchronized as possible, according to an adjustable scale factor, with the speed of the textile machine served.

Another purpose of the present invention is to

provide an electronic device for regulating and controlling delivery of yarn coming from feed units of textile machines which does not involve the use of complex and/or particularly costly technologies and which enables substantial reduction of processing times and of losses in productivity as compared to known techniques by managing the production processes in a more appropriate way.

The above and other purposes are achieved by an electronic device for regulating and controlling delivery of yarn coming from feed units of textile machines according to Claim 1, to which the reader is referred for reasons of brevity.

Advantageously, the regulation device according to the invention is made up of a d.c. brushless motor and an electronic circuit, which comprises a microcontroller that is able to control the r.p.m. of the motor and the currents in the phases.

An encoder, connected to the axis of rotation of the motor, enables detection of the r.p.m. and of the incremental position of the motor and comparison of said quantities with the speed of rotation and of the incremental position of the machine, this information being derived from the signals received from the main reference encoder.

The device can be remotely controlled and

programmed by means of an asynchronous serial interface of the RS485 half-duplex type, with which it is equipped.

Also provided are two inputs for the connection of sensors for arresting the yarn, of the Hall-effect type, an input available for a manual control for excluding arrest of the yarn, an output of an open-collector type for remote signalling of a condition of collective arrest, and some LEDs for remote display of a state of arrest.

A single 24-V d.c. supply voltage is provided.

Further purposes and advantages of the present invention will emerge clearly from the ensuing description and from the attached schematic drawings, which are provided purely by way of explanatory and non-limiting example of embodiment, in which:

- Figure 1 shows the path of the yarn which is reeling off a reel, in a generic textile machine belonging to the state of the art;

- Figure 2 is a partial perspective view of a ribbon-type positive feeder, which can be used for delivery of yarn in known textile machines; and

- Figure 3 is a block diagram of an electronic device for regulating delivery of yarn coming from a feed unit of textile machines according to the present invention.

With particular reference to the Figure 3, the main functional elements of the electronic device for regulating and controlling the delivery of yarn according to the present invention are represented by a microcontroller designated by 21, a signal and power analog section designated by 22, and a d.c. brushless motor 23 associated to a Hall-effect local encoder 27.

The microcontroller 21 receives from a buffer 24 of a serial line of the RS485 type the configuration commands, and transmits, upon command, the information regarding the current situation, driving the signalling outputs accordingly.

The above information is acquired by reading the logic signals coming from a set of sensors 25 for arrest of the yarn or from a manual command 20 for excluding said arrest by reading signals generated by a reference encoder 26 and comparing said signals with the signals coming from the encoder 27 fitted on the shaft of the motor 23.

Also present is an output of an open-collector type designated by 50 which can be used for remote signalling of a condition of collective arrest, and a number of LEDs 51 for remote display of a state of machine arrest.

By taking into account just the advance pulses, the microcontroller 21 calculates the difference between

the number of pulses received from the two encoders 26, 27, either incrementing or decrementing the count.

The instantaneous value totalized by the counter, with appropriate corrective factors that can be modified by manual commands issued on the serial line, is used as reference of speed of the analog and power section 22.

The output 40 of the microcontroller 21 is of the PWM type, which can be transformed into a voltage level thanks to the presence of a low-pass filter 28.

In addition, the microcontroller 21 sends further commands, designated as a whole by 29 in Figure 3, to the analog section 22 for switching of the phases, the said commands being defined according to the dedicated device used for controlling the current in the phases of the d.c. brushless motor 23. In particular, the said commands may consist simply of a dynamic-brake command issued when it is desired to stop the motor 23, or directly of the commands for enabling the three branches of the power bridge, acquired by the microcontroller 21 by decoding the signals H1, H2, H3 for the position of the rotor of the motor 23 with respect to the stator. The analog and power section 22 is made up of a signal portion and a power portion. The signal portion receives the logic signals H1, H2, H3 or CHA, CHB produced by one or more encoders 27 of the

motor 23 and, from these, via a frequency/voltage converter 39, derives a unidirectional tachimetric signal 41, of an analog type, which is compared with the speed reference 40 generated by the microcontroller 21 and processed by the low-pass filter 28.

The choice between the logic signals H1, H2, H3 or CHA, CHB depends upon the number of pulses per rev for a uniform movement of the motor 23 at low speed. In fact, exploiting all the signal edges, in the first case (using the signals H1, H2, H3) twelve pulses per rev are obtained, whereas, in the second case (using the signals CHA, CHB), with a 32-pole magnetized wheel, sixty-four pulses are obtained per rev.

The difference (signal 42) between the signals 40 and 41, appropriately filtered by the low-pass filter 30, is used as current reference for the next stage, designated as a whole by 31 in Figure 3.

Here it is compared with the signal 43 coming from the shunt resistor 32, which is proportional to the current circulating in the phases of the motor 23, generating the control signal 44 for the PWM modulator 33. The output of the latter (designated by 45) fixes the turning-on and turning-off times for the drivers 34 of the MOSFETs 46 of the power bridge 35, whilst the other control signals 29 received from the drivers 34 determine which MOSFETs 46 in each branch of the power

bridge 35 must switch and which must remain turned off.

The above control signals 29 may all come from the microcontroller 21 or else may be derived, in part, from the signals H1, H2, H3 for the position of the rotor of the motor 23. This depends upon the dedicated device used for controlling the current in the phases of the d.c. brushless motor 23.

The three-phase power bridge 35 is normally made up of six MOSFETs, designated by 46, and by six free-wheeling diodes, designated by 47, and the three branches 48 of the bridge 35 generate the three currents I1, I2, I3 circulating in the three phases of the motor 23 (a maximum current value per phase of approximately 1.5 A is reached).

In addition, since the motor is a d.c. brushless motor, at each instant it is possible to energize the three windings so as to obtain advance of the rotor according to the current position thereof. With the three canonical combinations, in one direction of use of the windings of the motor, which carry out energizing of just two windings at a time, it is possible to exploit a further three intermediate switching combinations, in which, alternately, one winding is connected to the positive side of the supply bus and the other two windings, simultaneously, to the negative side of the supply bus, or vice versa. There

are thus obtained six switches for each pole of the motor, to which there correspond six equidistant angular advances of the rotor.

The motor assembly of the entire electronic regulation and control device, in addition to the motor 23 proper (for which the model BLDC48 "Premotec" may be used), comprises an encoder 37 for detecting the position of the rotor of the motor 23, which generates the signals H1, H2, H3, and the local encoder 27, both of which are fitted on the shaft of the motor 23.

The local encoder 27 may be obtained using a magnetized wheel having a diameter that is compatible with the dimensions of the motor 23 and is equipped with thirty-two magnetic poles. For reading, pairs of Hall-effect sensors are preferably used so as to enable discrimination of the direction of revolution, whilst the signals generated may be the classic channels A, B (signal CHB), or else a clock having a frequency proportional to the r.p.m. of the motor 23 (which reaches a maximum of approximately 10 000 r.p.m.) and a bit for the direction of revolution (signal CHA).

The local encoder 27 may then be eliminated if the signals H1, H2, H3 enable a sufficiently regular movement to be obtained at a low r.p.m.

Finally, the electronic device comprises a local power supply 38 of a linear type, which enables a

reduced voltage of +5 V for supplying electric power to the logic 22, as well as a possible intermediate voltage for the drivers 34 of the power bridge 35, to be obtained directly from the 24-volt supply voltage V. The power of the bridge and the value of the said intermediate voltage depend upon the characteristics of the dedicated device used for controlling the current in the phases of the brushless motor 23.

Furthermore, an electrolytic capacitor of adequate capacitance provides local coverage of the current peaks absorbed by the motor 23 and initially absorbs the voltage peaks during deceleration, whilst the remaining energy must be absorbed by the 24-V d.c. supply bus 49 and dissipated upstream of the power supply 38.

The characteristics of the electronic device for regulating and controlling the delivery of yarn coming from feed units of textile machines, which forms the subject of the present invention, as well as the advantages, emerge clearly from the foregoing description.

Finally, it is clear that numerous variations may be made to the electronic regulation and control device referred to herein, without thereby departing from the principles of novelty inherent in the inventive idea. It is likewise clear that, in the practical

implementation of the invention, the materials, shapes and dimensions of the items illustrated may be any whatsoever according to the requirements, and may be replaced with other technically equivalent ones.

CLAIMS

1) An electronic device for regulating and controlling the delivery of yarn (18) coming from feed units of textile machines, the said electronic device being characterized in that it comprises means designed to vary the r.p.m. of a motor (23) so as to keep it synchronized, according to an adjustable scale factor, with the speed of the textile machine to which the regulation device is connected.

2) The electronic regulation and control device according to Claim 1, characterized in that said motor (23) is constituted by a d.c. brushless motor and said means for varying the r.p.m. of said motor (23) comprise at least one electronic circuit, which includes at least one microcontroller (21) that is able to control the r.p.m. of the motor (23) and the currents (I1, I2, I3) circulating in the phases of said motor (23), said electronic regulation and control device further comprising at least one local power supply (38) for supplying electric power.

3) The electronic regulation and control device according to Claim 2, characterized in that said d.c. brushless motor has three windings, which can be energized at any moment so as to obtain advance of the rotor according to the current position thereof in so far as, with three combinations of use, in one

direction of use of said windings of the motor, which envisage energizing of just two windings at a time, it is possible to exploit a further three intermediate switching combinations, in which, alternately, one winding is connected to the positive side of the supply bus and the other two windings, simultaneously, to the negative side of the supply bus, or vice versa, so to obtain six switchings for each pole of the motor, to which there correspond six equidistant angular advances of said rotor.

4) The electronic regulation and control device according to Claim 2, characterized in that said electronic circuit comprises at least one first encoding element (27), connected to the axis of rotation of said motor (23), which enables detection of the r.p.m. and of the incremental position of the motor and comparison of said quantities with the speed of rotation and the incremental position of said textile machine, this information being derived from the signals received from at least one second reference encoding element (26).

5) The electronic regulation and control device according to Claim 1, characterized in that it is envisaged to install at least one asynchronous serial interface, which, by means of a buffer (24), enables remote control and programming of said device.

6) The electronic regulation and control device according to Claim 4, characterized in that said microcontroller (21) calculates the difference between the number of pulses received from said encoding elements (26, 27), either incrementing or decrementing the count so that an instantaneous value totalized by the counter, with appropriate corrective factors that can be modified by manual commands, is used as reference of speed of an analog and power section (22) of said electronic circuit.

7) The electronic regulation and control device according to Claim 6, characterized in that said microcontroller (21) has at least one speed reference (40) at output, which can be converted into a voltage level thanks to the presence of a low-pass filter (28), said microcontroller (21) being moreover used for sending to said analog section (22) further control signals (29) for switching of the phases of said motor (23) which are defined according to a specific device used for controlling said currents (I1, I2, I3) circulating in the phases of said motor (23).

8) The electronic regulation and control device according to Claim 7, characterized in that said analog and power section (22) comprises a signal portion, which receives a series of logic signals (H1, H2, H3; CHA, CHB) produced by said first encoding element (27)

of the motor (23) and in that, from these, via a converting device (39), it derives a unidirectional tachimetric signal (41), which is compared with said speed reference (40) at output from the microcontroller (21) and processed by the low-pass filter (28).

9) The electronic regulation and control device according to Claim 8, characterized in that the difference (42) between said speed reference (40) and said tachimetric signal (41) is filtered and then is used as current reference for a subsequent stage (31) of said analog and power section (22), in which it is compared with a signal (43), which is proportional to the currents (I1, I2, I3) circulating in the phases of the motor (23), generating a control signal (44) for a modulator device (33), the output of which (45) fixes the turning-on and turning-off times for a set of driving means (34, 46) of a power circuit (35), which further uses said control signals (29) that come from said microcontroller (21) or can be derived, at least in part, from a set of signals (H1, H2, H3) for the position of the rotor of said motor (23) and can be derived thanks to encoding means (37).

Fig.1

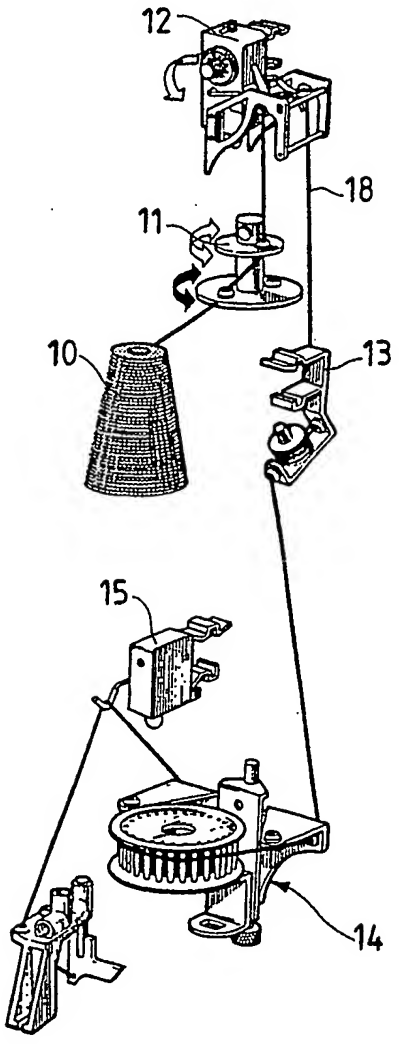
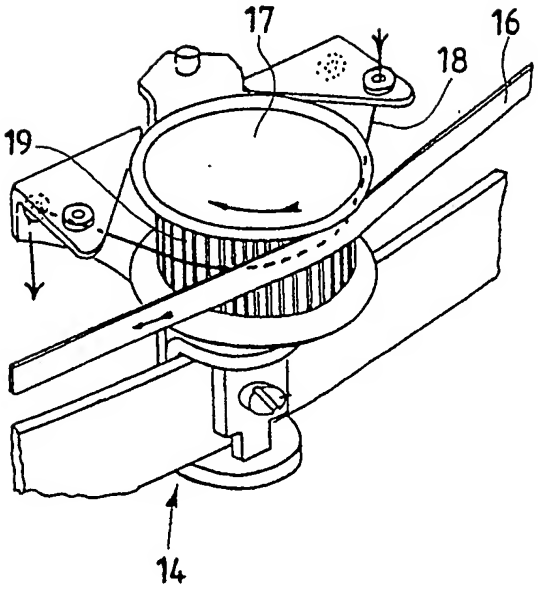


Fig.2



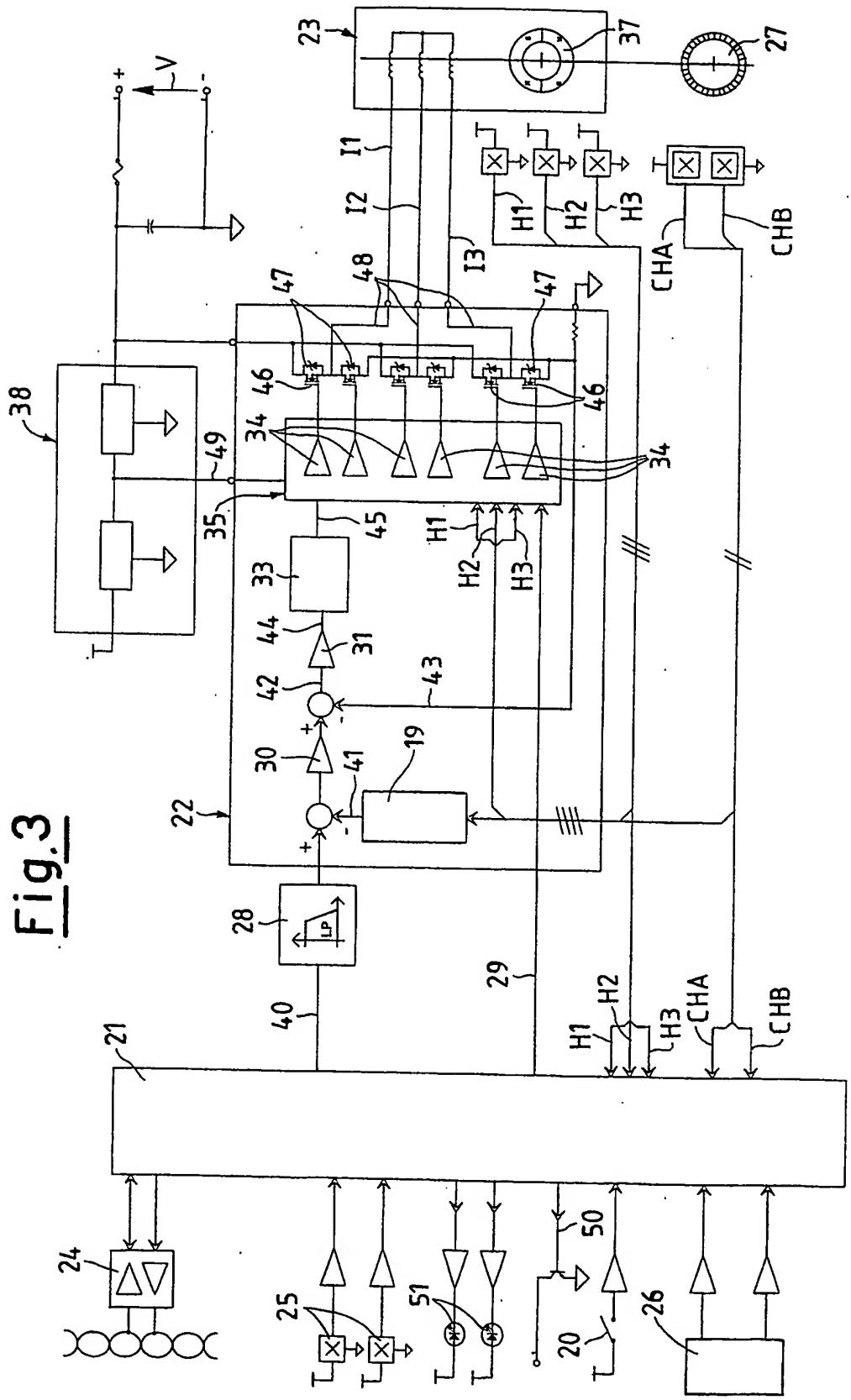

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Fig.3

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP 02/11137

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 D04B15/48 B65H51/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 D04B B65H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 January 2003	05/02/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Van Gelder, P

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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